FISHERIES RESEARCH IN *Saskatchewan*

CONSERVATION BULLETIN No. 3

FOREWORD

This bulletin is the third of a series, the purpose of which is to describe the natural resources of Saskatchewan and outline sound methods for their management and utilization. The publications are intended to provide those people who are interested in natural resources with specific information of a semi-technical nature. The main consideration in preparing the material is to provide those who are, or may become, community leaders in conservation, with a sound basis for formulating opinions on this important subject.

Some of the bulletins will deal mainly with individual species; some with broader aspects of management and harvesting. In all cases they will attempt to convey some knowledge of the lives of plants and animals and their place in the vastly complicated web of nature, for such knowledge is essential to an understanding of conservation. Equally important is a conception of the place of man in the natural scheme of things. Adequate care of natural resources has become the most vitally important aspect of human existence on this increasingly crowded earth, and man may reap well-being only by sowing understanding.

Other bulletins in this series published to date are:

No. 1: Beaver in Saskatchewan.

No. 2: White-tailed Deer in Saskatchewan.

A complete list of publications is available from your local Conservation Officer or from the department offices at Regina.

SASKATCHEWAN

Department of Natural Resources

CONSERVATION INFORMATION SERVICE

Hon. A. G. KUZIAK
Minister

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INTRODUCTION

During the past decade or so, the market demand for food fish from Saskatchewan lakes has become almost insatiable, due largely to the booming popularity of fish sticks in the United States.

In the same period, angling by Saskatchewan residents has increased ten-fold or more. In 1946, less than 8,000 angling licences were sold in the province. By 1956 the figure had risen close to 80,000, and is increasing year by year.

This same decade has also produced an outstanding example of the value of our northern lakes as a tourist attraction. During the five years following the completion of the highway to Lac la Ronge, income from sport fishing in the la Ronge area rose from nil to well over a million dollars.

These facts illustrate the tremendous value of Saskatchewan's fisheries resource, and indicate something of its future potential. The facts also indicate that commercial fishermen and anglers will make increasing demands on all accessible Saskatchewan lakes.

Under these circumstances, it is essential that adequate fisheries management plans be formulated and carried out. The development of such plans is completely dependent on a continuing program of research, conducted by skilled biologists on every major water body in the province.

Limnology and fisheries management are among the newest of all the sciences. They are based on a mere 30-odd years of intensive scientific research, as compared with the 100 or more years of research and experimentation upon which scientific agriculture is based. However, in spite of the comparatively recent application of the scientific approach, the value of fisheries management based on adequate research has been amply demonstrated in scores of Canadian inland waters, including several Saskatchewan lakes.

During the next decade or so, this science will to some degree affect the well-being of the majority of Saskatchewan citizens. Some thousands, who depend for their income on commercial fishing, mink ranching or tourism, will be vitally affected. Other tens of thousands, who derive satisfaction from holiday excursions to good angling lakes, will be affected to a significant degree.

The successful management of the fish population of any lake is dependent on an adequate research program and a clear understanding by commercial and sports fishermen of the need for research and management.

The financing of an adequate research program depends in part on public understanding of the practical value of such research. However, fish culture and the research upon which it is based have been given almost no popular attention in western Canada.

In consideration of the need for more general understanding of the field of fisheries research and management by the many thousands who annually derive income or enjoyment from Saskatchewan's lakes, the intention of this bulletin is: to briefly describe the flora and fauna of Saskatchewan lakes, to indicate something of the complicated relationships of these living organisms to their environment and to each other, and to show how the fisheries researcher assesses all these factors in terms of the ability of a lake to produce fish.

THE UNDERWATER UNIVERSE

The usual description of a northern Saskatchewan lake is made in terms of mile-long white sand beaches, sparkling blue waters, the rugged harmony of jack pine ridge framed between granite shore and pale blue northern sky. These are the ordinary terms, and with suitable additions—like sudden squalls, deer flies, blackflies, mooseflies, sandflies, idyllic evenings chatting around a campfire dining on tea, bannock and ponassed fish—sum up the impression gained by the average angler. The lake itself is probably like a watery, almost deserted waste to him.

The average person may note that a lake is shallow or deep, clear or murky, studded with islands or simply a great expanse of open water, and that few or many big fish are biting, but beyond these observations he is unlikely to go. Yet around him and beneath him as he cruises over the lake is a small universe with a climate of its own, distinct from the climate of sun, wind and rain with which he is familiar; a universe wherein millions of animals of many species eat, fight for survival and reproduce their kind, each dependent upon each, and all dependent on the peculiar character of their world of water.

THE BIOLOGIST'S LAKE

The fisheries biologist, cruising over the same body of water, conducting casual observations, will find clues as to the state of the underwater universe: the track of caddis larva on the fine sand of the shallow water areas; the floating discarded pupa case of the mayfly newly emerged; the swarms of midges rising like columns of smoke above the tallest island spruce bluff; the intense spawning activity of a horde of spot-tail minnows in a rocky crevasse; the emergence from the lake surface of the dorsal fins of whitefish feeding on rising mayfly and midge larvae—all these offer a slight, very slight indication of the workings of the universe below the water surface.

The biologist may find reason to believe that certain species of fish are likely to be plentiful, and that others

The "Namaycus" used for biological survey work on Lac la Ronge.

may be searee. For example, eaddis fly, mayfly and midge larvae provide food for bottom-feeding fish, and if they are plentiful in a lake, there is a good ehanee that whitefish and suckers will be plentiful, too. Plenty of these bottom feeders indieate a possibility that there may be plenty of piekerel. Great numbers of shallow water minnow and pereh may mean that northern pike will be plentiful.

However, sueh off-the-euff guesses ean be drastically misleading. To get a elear pieture of the life system of a lake, the researeher must earry out hundreds of exaeting and sometimes eomplicated tests. Having made the tests, he must weigh his information in the light of what similar information has meant in hundreds of other lakes on the continent. Finally, he ean arrive at a valid estimate of the poundage of eaeh speeies the lake will produee annually without damage to the populations. His findings are vitally important, beeause over-fishing of any speeies ean be most harmful to the produetivity of a lake, and underharvesting is wasteful.

THE PATTERN OF LIFE IN A LAKE

Beneath the surfaee of the lake, hordes of tiny living plants grow and reproduce while floating freely in the water. These plants are used as "pasture" by great hordes of tiny free-swimming water animals such as water fleas and small fish. The tiny animals are eaten by larger fish, like northern pike fingerlings or eisco, whieh in turn are eaten by the adult predators—pike, pickerel, trout, grayling, burbot, etc. The tiny free-floating plants and animals are of many varieties, from minute one-eelled algae to the one-eyed animal ealled eyelops, as large as a small grain of sand. Lumped together, these many speeies of free-floating plants and animals are ealled plankton. The plant plankton (phytoplankton) depends on sunlight for its growth—as do all plants—and the animal plankton (zooplankton) depends mainly on the plant plankton for food. The main plankton erop grows within 30 feet of the surfaee of the lake, because sunlight seldom penetrates deeper than that in signifieant quantities.

The plankton organisms that are not eaten eventually die and drop to the bottom, like a continuing fine rain from the upper regions of the lake. Dead plankton, along with sand and soil particles, forms the typical deep-water ooze. In this bottom ooze are found vast hosts of other lake animals: tiny elams, freshwater shrimps, larvae of fishflies and mayflies, aquatie earthworms and others, that derive their nourishment from the dead, deeaying plankton. The ooze-dwelling ereatures provide food for whitefish, suekers and other bottom-feeding fish, and they in turn may be eaten by predators, sueh as pike and piekerel.

This is the general pattern of life in freshwater lakes, not only in Saskatehewan but throughout the world's temperate zones. However, within and around any given lake are a thousand factors which modify this general pattern. It is these factors that the researeh biologist is seeking to understand when he eonducts a limnological survey of a lake. For example: What is the mineral eontent of the water? What is the oxygen content at various levels at all seasons? What is the temperature at various depths throughout the year? How many pounds of plankton are there

Imprints of scales are made on soft plastic and then projected on a screen. Rings on the scales indicate the growth rate of the fish.

per acre in the spring, midsummer or fall? How many pounds of bottom organisms are there per acre during each of the four seasons? Is the water deep or shallow? What is the shape of the shoreline and the profile of the bottom? Is the water clear or murky? What are the predominant species of fish, what are their sizes and ages and how many pounds are there per acre? These are some of the more important questions to which the biologist must find the answer. The answers differ in every lake, and each answer has a distinct bearing on the ability of a lake to produce fish.

Most of the answers come only as the result of dozens of exacting tests and measurements, many of which must be carried out on the lake and the rest in a laboratory. The more important tools of the fisheries biologist's trade include a well-equipped laboratory, a boat, gill nets and seine nets, a reversing thermometer, a small dredge, a sounding lead, portable chemical kits of various types, maps, dredge screens of various meshes, plankton nets, camping equipment, buckets, a variety of sample bottles, and a brass bottle specially made for collecting water samples at various depths. The answer to any given question has a distinct bearing on how productive the lake is, for reasons which will be outlined in the following sections.

THE SCIENTIFIC METHOD

MINERALS

The conservationist's truism, "all life is derived from the soil", applies to fisheries quite as definitely as it does to forestry or agriculture. The pure water that falls as rain or snow would be unproductive but for the fact that it percolates down through the soil, dissolving minerals as it goes and carrying them down to the lake. The fisheries biologist considers soft water quite suitable for washing in, but definitely poor for growing fish. The tremendous amount of plant plankton required to support a large fish population cannot grow in a soft-water lake.

Thus, one of the basic steps the biologist takes is to determine the mineral content of the lake water. This is done by means of sampling the lake at various depths. Samples are taken using a brass water bottle which may be corked at the desired depth by means of a spring mechanism which is triggered by a "messenger"—a heavy brass ring which is run down the cord. The biologist puts part of the water in a sample bottle. When several samples have been taken at various seasons, they will be analysed in the Fisheries Laboratory at the University of Saskatchewan in Saskatoon, and will provide a record of one of the basic factors that have a bearing on the productivity of the lake.

What is the usual amount of minerals in solution in Saskatchewan lakes? The amount varies surprisingly, from an extreme low of only 30 parts of minerals per million parts of water in Reindeer Lake to a fantastically high 118,000 parts per million in Manitou Lake. As a point of comparison, the mineral content of the ocean is 35,000 parts per million.

The most important elements are phosphorous, calcium, sodium and iron, with tiny amounts of "trace" elements which are essential to growth in a way not yet understood. Compounds of nitrogen, sulphur and carbon are also found in solution in fresh-water lakes. Some of the southern lakes hold huge quantities of magnesium salts in solution. Too small an amount of any single mineral may set a definite limit on the amount of fish a lake is capable of producing, and too high a mineral content may be equally harmful.

The amount of minerals in a lake usually depends on the kind of drainage basin in which the lake is located. The lakes of the soil-deficient Pre-Cambrian Shield run from 30 to about 100 parts of mineral per million parts of water. Hunter Bay of Lac la Ronge, for example, has 110 parts per million of dissolved minerals, being completely in a Pre-Cambrian basin. Lac la Ronge proper, located half in and half out of the Pre-Cambrian, and with its main inflow of water from the south, via the Montreal River, has 130 parts per million. Lake Waskesiu has 170; the Qu'Appelle Lakes 1,000; Last Mountain Lake approximately 2,500; Basin 12,000, Manito 20,000 and the Quill Lakes up to 70,000 parts per million. The highly saline lakes are not generally suitable for the natural maintenance of large and diverse fish populations, partly due to the fact that spawning is usually not successful in such lakes.

One of the most thought-provoking summaries of the place of minerals in

lake life was made by the limnologist Forbes, who made the brief, but loaded comment: "The aquatic population of a lake or stream is . . . sustained by the wastes of the land, materials which would otherwise be carried down practically unaltered to the sea; and rivers and lakes may be looked upon as a huge apparatus for the arrest, appropriation, digestion and assimilation of certain raw materials about to pass from our control".

It should be kept in mind, however, that this process of "salvaging" minerals lost from the land is not very efficient. Only a tiny fraction of one per cent of the minerals in a lake and river system are ever converted into fish.

ACIDITY AND ALKALINITY

Most of our freshwater fish species achieve their best growth and development in slightly alkaline water. Water with high acid content, such as muskeg water with its humic acid content, is relatively sterile and unproductive, since plankton and bacteria do not readily grow in it. Much of the acidity in freshwater lakes is due to carbon dioxide produced by the rotting of bottom organisms such as dead plankton.

The bottom layer of water in a deep lake doesn't circulate very much, except in the spring and fall, so water samples must be collected from two or three different levels in the lake in order to get a clear picture. Analysis of the water must be done as soon as the sample is taken out of the lake, because if the sample is left too long, the carbon dioxide is lost and the results of the test would be misleading. The biologist uses a small chemical kit made up especially for the test.

A reversing thermometer, used for measuring temperature and obtaining water samples at various depths.

WATER TRANSPARENCY

Plant plankton depends on sunlight for growth, just as land-growing plants do. For this reason, clear water is usually a better producer of plankton than murky water, and consequently a clear lake will be a better fish producer—all other things being equal.

Transparency is measured simply by lowering a 10-inch white disk (called a Secchi's disk) into the water. The depth at which it is visible is a measure of the light penetration into the water.

In some lakes, such as Great Slave, in the Northwest Territories, the disk may be visible in water up to 45 feet deep. Hunter Bay on Lac la Ronge has a reading of about 24 feet. Wappawekka Lake, just to the southeast of Lac la Ronge, has a reading of less than nine feet. Some of the southern lakes, like the Qu'Appelle chain, have a reading of only a few feet, and at certain periods only a few inches.

Low light penetration may result from a heavy plankton crop, in which case it means a food supply for a large crop of fish. In other lakes, a high silt content may block the rays of the sun. Sometimes the silt is due simply to the natural makeup of the drainage basin. In other cases, high silt content is the result of poor farming practices which allow a large surface run-off of dirty water. Pollution due to the wastes from mines and mills may reduce the light penetration seriously. By reducing the amount of sunlight penetration, such siltation means a low plankton crop and consequently a low fish crop.

TEMPERATURE AND OXYGEN CONTENT

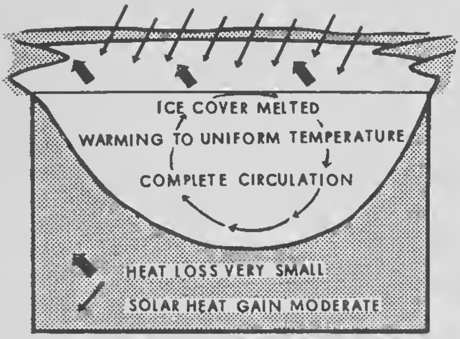
All living things in a freshwater lake require oxygen for life, exceptions being certain types of bacteria and possibly some of the ooze-dwelling bottom animals. Thus, the oxygen content of lake water during any day of the year may be a critical factor in the survival of fish.

Plants give off oxygen, and they also "breathe" oxygen. This applies to the tiny plant plankton as well as to the larger plants of the lake. During the sunshine period of the day, they are likely to give off more oxygen than they use. During this period, the upper, plankton-producing layer of water is likely to have a high oxygen content, because the phytoplankton, in their billions, release oxygen which is immediately dissolved in the water. At night and on dull days, the plants use oxygen but produce none at all, so the supply of oxygen drops off quickly. In winter the oxygen depletion in some lakes may be serious, especially in shallow lakes with a great deal of vegetation. The first heavy snowfall after freeze-up blocks out the sunlight, and in two or three days the vegetation may have used up all the oxygen in the water, or at least reduced it to a level at which most fish cannot live, causing heavy winter kill.

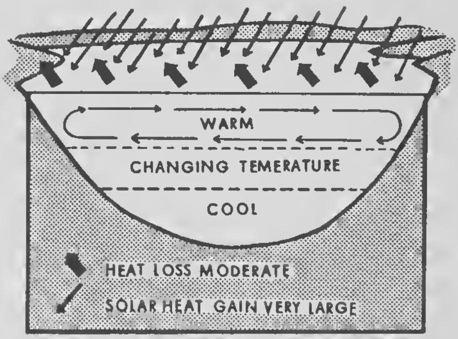
Lack of oxygen during the winter is the main reason why thousands of otherwise suitable ponds in the agricultural parts of the province can't be stocked with fish. Only in the Cypress Hills and the Great Sand Hills is the stocking of ponds generally practicable. Here the depth of the average pond may be greater, plant life less, snowfall smaller and winters shorter and milder.

THE ANNUAL TEMPERATURE

Because of the peculiar expansion of water, changes in density with heating and cooling are important. The sun and the wind are the two great energy sources driving this system of circu-



SPRING OVERTURN



SUMMER STRATIFICATION

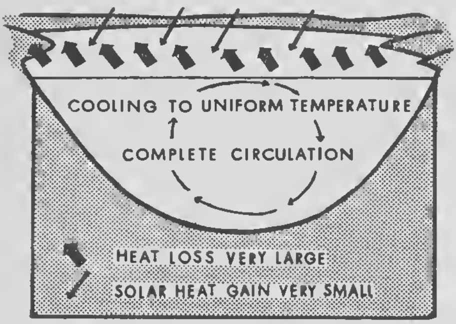
During the ice-free period, the action of the wind adds oxygen to lake water. Each white-capped wave brings oxygen out of the air into solution in the water, and the currents created by the wind cause the oxygenated water to circulate down through the lower depths of the lake.

There are often circumstances when the action of the wind can't circulate the water completely. A case in point is the few lakes that have an inflow of highly mineralized water, which is heavier than the surface water of the lake. The heavy water sinks to the bottom and even a heavy gale may not mix the oxygen-rich top layer with the oxygen-poor bottom layer.

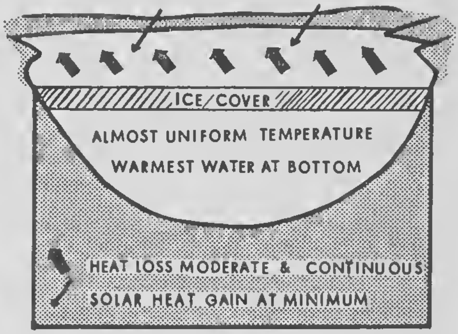
In most Saskatchewan lakes, such stratification due to mineralized water is not very important. However, stratification and difficulty of mixing does occur in most temperate-climate lakes, due to temperature differences between the surface water and the deeper water. In early summer the top 30 or 40 feet of water warms up, sometimes going as high as 70 degrees Fahrenheit or more. The water in this top layer weighs considerably less per cubic foot than the water in the unwarmed lower layer, and as a result little mixing takes place during the summer months. Consequently, the deepest holes in a lake may have too little oxygen to support fish, so even the cold-water fish like trout must move into warmer water nearer the surface in order to get enough oxygen.

In the fall, when the surface temperature drops to 39.2 degrees, the surface water becomes heavy and sinks. Water is at its heaviest at 39.2 degrees Fahrenheit. As the surface water sinks at any given point, it displaces water close to the bottom which is warmer (and lighter in weight). These vertical currents cause a certain amount of mixing between the oxygen-rich top layer and the oxygen-deficient bottom layer. Then come the fall windstorms which complete the mixing of the water layers. This whole phenomenon is called the "fall

lation each year. The critical period when dissolved oxygen may be important are summer stratification and winter stagnation.



AUTUMN OVERTURN



WINTER STAGNATION

overturn" of the lake. At this period the whole lake, from surface to bottom, has a temperature of about 39 degrees, and has a high oxygen content throughout. During the overturn, fish may be found anywhere in the lake.

Then, with increasing cold, the surface water expands slightly, remains in the upper layer, and freezes over. Once again the lake becomes quiet, with the surface water at 32 degrees and the bottom remaining at between 39 and 40 degrees. The fish remain as deep as possible, in order to be in the warmest water.

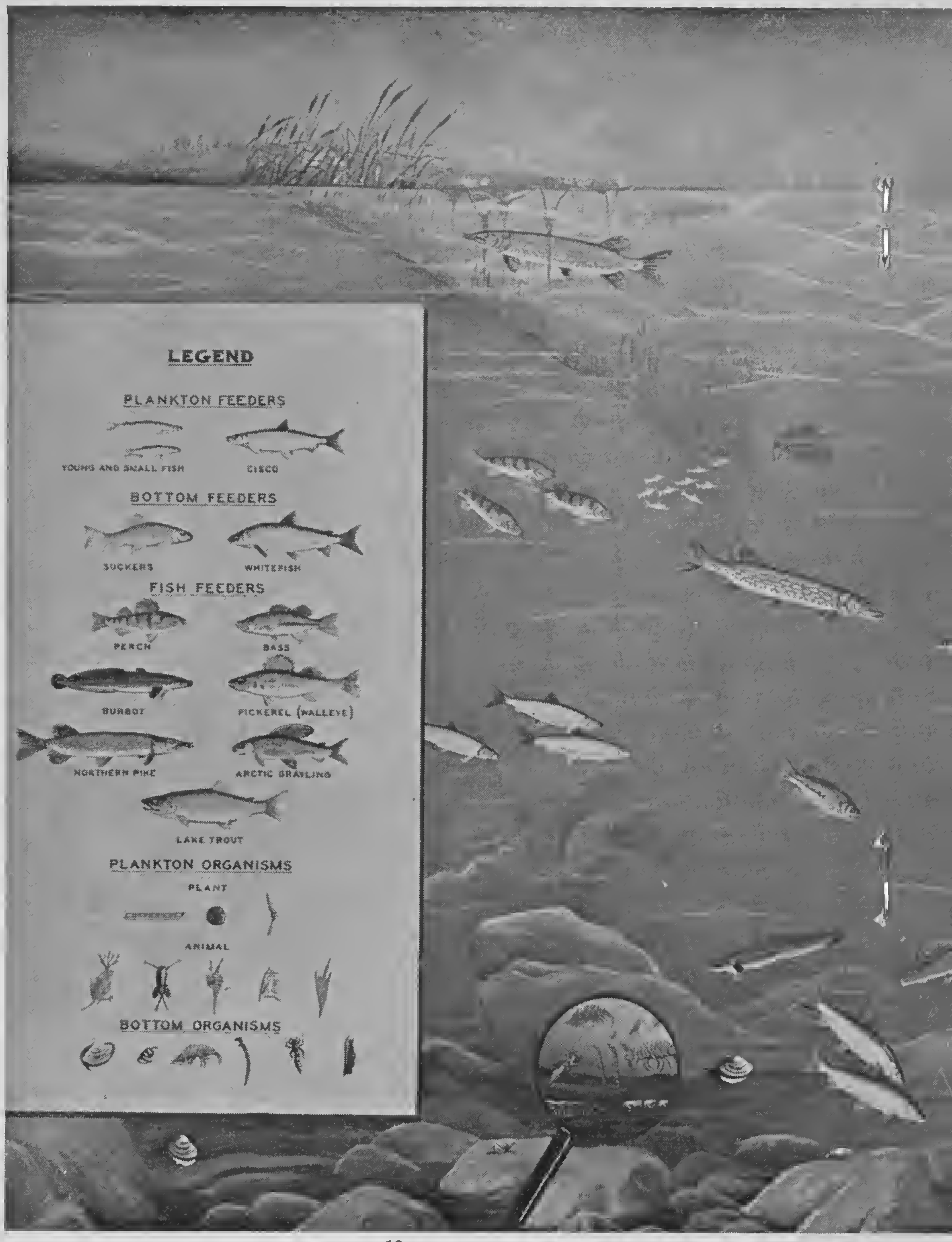
During the late winter they are likely to be plentiful also near the mouths of rivers, where oxygen-rich waters and food are poured into the lake. Except for the small amount of oxygen from river water, the supply provided by the fall turnover must last all winter.

After spring breakup, the surface water rises to 39.2 degrees, and the spring overturn occurs in much the same manner as the fall overturn. Once again fish can be found anywhere in the lake. And once again the surface water becomes lighter as its temperature goes up, and the summer period of stagnation begins.

The timing of this process of stagnation and overturn is slightly different in each lake. It depends on the depth of the lake, the amount of shelter from wind provided by hills or trees along the shore, and the amount of solar heat absorbed by the lake. The amount of oxygen in solution in a lake after each overturn is a very important factor in fish production, because the fish depend on this supply during the entire next season.

PLANKTON

The average person, drinking a copious draught of clear, clean lake water, is probably only dimly aware that he may be consuming a considerable variety of plants and animals in the process—possibly a million plants


LEGEND
PLANKTON FEEDERS
YOUNG AND SMALL FISH
CISCO
BOTTOM FEEDERS
SUCKERS
WHITEFISH
FISH FEEDERS
PERCH
BASS
BURBOT
PICKEREL (WALLEYE)
NORTHERN PIKE
ARCTIC GRAYLING
LAKE TROUT
PLANKTON ORGANISMS
PLANT
ANIMAL
BOTTOM ORGANISMS

LIFE IN A LAKE

Here the artist has depicted some food relationships of the main groups of organisms in an aquatic environment. The habitats of the various fish species and the conditions of the underwater universe are suggested.

and ten thousand animals, if the drink is a long one.

The plants, of which there are about 100 species important to fish production, consist mainly of green algae, blue-green algae and tiny one-celled diatoms. They are true plants although they have no stems, leaves or flowers. With the aid of sunlight they convert carbon dioxide and hydrogen into vegetable matter just as land-growing plants do, and they respire and excrete oxygen in the same manner. They are usually made of one to 20 cells. The minute diatoms measure between five thousandths and 16 thousandths of an inch. The larger plankton algae may be as large as a hundredth of an inch in diameter.

A net with very fine screen is used for collecting samples of plankton. The volume and type of plankton indicate the population of plankton-feeding fish that can be supported by the lake.

The plant plankton crop is comparable to the grass in a field. Animal plankton grazes on phytoplankton just as livestock graze in the fields, converting plant matter into animal matter. Some of the animal plankton, such as certain species of protozoa, are too small to be seen with the naked eye. Higher on the size scale are the rotifers, like tiny worms each with a "wheel" of vibrating hairs to propel it through the water and collect its food. There are dozens of species of these, varying up to a twentieth of an inch long. The one-eyed cyclops, as big as a small grain of sand, moves through the water with little jerks and is a numerous and valuable fish-food species in most lakes. The largest of the important zoo-plankton species are the water fleas, the larger members of this tribe being as big as a pinhead.

There may be between 5,000 and 150 million plant and animal plankters in a single litre (less than a quart) of water. A representative acre of a Saskatchewan lake may average a 30 pound standing crop of plankton. Lac la Ronge, for example, runs at about 56 pounds per acre during the summer and 10 pounds per acre during the winter. The less productive Hunter Bay usually has about half as much. Last Mountain Lake runs as high as 150 pounds per acre in the summer.

The lifespan of plankton varies between just a few days and as long as six weeks. In summer, there may

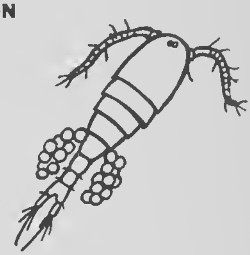
PLANKTERS AND BOTTOM ORGANISMS IMPORTANT TO FISHES IN OUR LAKES

(Greatly Enlarged)

ANIMAL PLANKTERS OR ZOOPLANKTON

NOTHOLCA

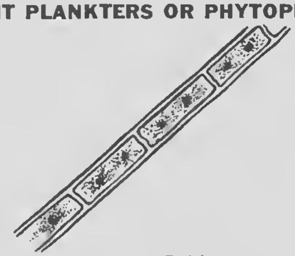
DAPHNIA



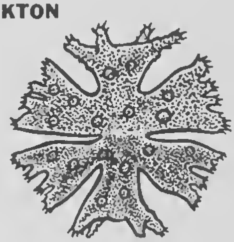
CYCLOPS

PLANT PLANKTERS OR PHYTOPLANKTON

CERATIUM



ZYGNEMA

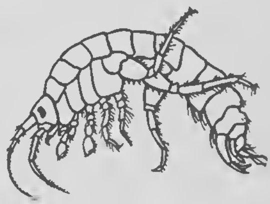


MICRASTERIAS

BOTTOM FAUNA

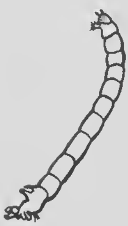
PHYSA

SPHAERIUM

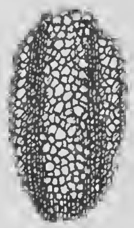


AMPHIPODA

MAYFLY NYMPH



CHIRONOMUS



CADDIS-WORM CASE

be a complete turnover of the crop in seven or eight days. The turnover takes longer in winter. Accordingly, during the productive summer, the continuing fallout of dead plankton toward the bottom of the lake may total 200 pounds or more per acre per month, most of which decomposes before reaching the bottom.

Occasionally, a great surge of plankton growth may occur over a period of a week or two. During such a "pulse", the plankton crop may stand at several times the summer average.

In the main, plankton is completely beneficial to the lake, but under certain conditions a heavy crop of blue-green algae may produce water conditions that are toxic to fish, killing them in large numbers. This occurs periodically in the Qu'Appelle chain and Last Mountain Lake as well as in other Saskatchewan lakes that are located in fertile basins.

The fisheries biologist uses a plankton net to collect his samples and estimate the ability of a lake to produce this important crop. The net is cone-shaped, with a collecting cup at the end of the taper. It is made of silk bolting cloth with 30,000 meshes to the square inch—which means that the individual openings of the mesh are about 16 thousandths of an inch across. Even with a net this fine, only a fraction of the total plankton is strained from the water that passes through the net. The rest of the tiny plants and animals slip through the meshes and escape. However, the net catches the most important fish-feeding plankton, and the biologist is able to make a shrewd estimate of the amount of plankton that slipped through the net.

The process of converting plant plankton to fish is not particularly efficient. The animal plankton grazes on the plant plankton. These are eaten by insects, larvae, small fish, and a few large species with gill strainers, such as ciscoes. The plankton that is not consumed drops to the bottom and either decays or is eaten by bottom animals, which in turn are eaten by whitefish or suckers. Then a portion of the plankton-eating fish and bottom-feeding fish are consumed by the predatory pike, pickerel, trout, etc., and the fish-production food chain is complete. During this process, less than one-tenth of one per cent of the plant plankton may be converted into fish, and only a small percentage of the total fish production is available for the use of man. However, without plankton, there would be no fish at all.

THE BOTTOM ORGANISMS

On a warm, windless day the chironomid (fishfly) swarms rise like smoke over the shores and islands. The swarms are mainly composed of males. The females fly into the swarm, mate and either fly or are blown out over the water. There they lay their eggs and die, returning to the element that nurtured them.

The eggs drop down to the bottom ooze, where they soon hatch into larvae. Some fishflies have one-year life cycles, others remain as larvae and pupae for up to five years. There are several hundred species of these "non-biting midges" in North American lakes. The larvae, popularly called bloodworms because of their color, usually feed on the bottom ooze—the continuing fallout of plankton from the upper water layer. Some species of bloodworms are predators, carrying on a slow-moving war to the

Organisms which provide food for bottom-feeding fish are screened from dredgings and preserved for laboratory analysis.

death with their plankton-scavenging cousins in the ooze and decaying matter of the bottom.

The emergence of any given chironomid species occurs with explosive suddenness. At some time during the warm weather the larvae become mobile pupae. In a week or two, usually at night, they rise to the surface to emerge from their pupal skins. The skin is then used as a raft for the brief moments until a breeze dries the folded wings and the adult fishfly takes to the air. During the period of emergence, the whitefish and cisco feed at the surface, breaking water with their dorsal fins as they suck in the surfacing pupae.

In their hundreds of millions, the lake's total population of a species of fishfly emerges, swarms, mates, and lays its eggs with tremendous intensity for a few days, then dies and is replaced over the shorelines by equal hordes of another species. This life cycle is typical of other aquatic insects like mayflies and caddis flies, although each species has its own individual peculiarities.

Fishfly larvae are by no means the only bottom animals that provide fish food. Amphipods—tiny freshwater shrimps—abound in most of the northern lakes, and small clams about the size of a match head are fairly plentiful. Aquatic earthworms

are fish food too, and there are a number of species of roundworms of minor significance.

In analyzing the amount and kind of bottom fauna in a lake, the biologist uses a small dredge with which he scoops up bottom ooze in samples of about a gallon per haul, from scores of points in the lake. The ooze is then washed through a series of fine screens, which allow the sand and decaying vegetation to pass through, but hold back the bottom fauna. The various species of animals are then sorted out, counted and placed in alcohol for more detailed analysis and weighing in the laboratory.

One such sampling test, carried out on Great Slave Lake, revealed a population of 1,300 bottom-dwelling animals per square yard, which amounted to 28 pounds per acre, or 2.2 pounds per acre dry weight. By comparison, Waskesiu has 22 pounds per acre dry weight; Lake Athabaska has 3.6, Lac la Ronge has 13 and Hunter Bay 11 pounds per acre. Generally speaking midge larvae make up the biggest proportion of bottom fauna in the southern, sedimentary lakes of the province, whereas in the deep Pre-Cambrian lakes freshwater shrimps and small clams are the most important fish food.

DEPTH AND SHAPE OF THE LAKE BOTTOM (Morphology)

The acreage of shallow-water areas in a lake governs that lake's productivity of small minnows, trout-perch and similar species of small forage fish. The amount of shallow-water vegetation may affect the winter oxygen supply. The deepwater areas in turn may provide a summer refuge for coldwater species such as trout. The total volume of water in relation to the volume of the plankton-producing upper layer will have a direct effect on the winter oxygen supply available. For these reasons and others, it is important that the biologist know the depth and shape of the lake bottom. Thus, during the course of a survey, hundreds of soundings must be taken, and a complete depth-sounding map is prepared for use during the final analysis of the lake's productivity.

THE FISH

The fisheries biologist makes no attempt to "fish out" a given acre or two of a lake in order to find out how many pounds per acre there may be of all species. This simply wouldn't work unless by an extravagant stroke of luck he picked an area that was exactly representative of the whole lake. Such an area would have to include the deepest portion of the lake, a suitable shallow water area, an area of bottom containing typical bottom ooze, and so on down a long line of conditions that couldn't possibly be filled. Consequently, the biologist must seek his answer by more roundabout methods.

During his lake survey, the biologist sets strings of nets varying from very small one-inch mesh up to the very large six-inch mesh. The fish caught vary from six inches in length to the largest predatory trout and pike in the lake. He weighs each one, measures its length, notes its sex, and takes a few scales so that under a microscope in the laboratory he can determine its age.

From these data the biologist can learn a number of things. He can learn how quickly the fish are maturing. He can deduce whether fish like cisco, suckers and whitefish are numerous enough to adequately feed the predators such as pike, pickerel and trout. The usual proportion in a healthy lake is 10 pounds of forage fish for one pound of predator fish. He can learn of any possible parasite infestations. He can learn something of feeding habits by examining stomach contents. With inshore sweeps of small-mesh seine nets he can learn how numerous are the small fish species. In one lake a short drag with a 30-foot seine yielded 6,000 spottail minnows.

LAKE ECOLOGY

In the foregoing sections, it has been shown how factors like light, minerals, oxygen and so on affect the ability of a lake to produce fish. In summing up the vast amount of data he has collected, the biologist must consider each of these factors individually, but he must also weigh each one against all the others. Only when he has assessed these interrelationships can he arrive at valid conclusions as to the fish-producing capacity of the lake. The study of such interrelationships is called "ecology".

A single weak link in the ecological "chain of production" can cause a lake to be unproductive. For example, Sandy Lake in Prince Albert National Park contained no trout at all, and the pike were poor. A limnological survey indicated that the physical conditions of the lake were such that both pike and trout should have thrived there. Depth, temperature, oxygen content and other factors seemed favorable. Why, then, were there so few of the major predatory game fish? The biologists came to the conclusion that it was because suitable forage fish were in short supply. To rectify this deficiency, they recommended stocking the lake with ciscoes.

Lakes like Basin, Redberry and many more with poor drainage build up a high mineral content due to evaporation. In many cases such lakes have been found suitable for whitefish and even game fish except for the fact that some little-understood conditions prevent successful spawning. In lakes like this, stocking with small fish (fry) has been successfully carried out.

Geographical location, local topography and climate are, of course, factors in lake ecology. Wollaston Lake in the north and Last Mountain Lake in the south offer outstanding examples of contrast due to these factors. Wollaston, located far to the north, has somewhat less effective sunlight than Last Mountain. The sun's rays enter the lake at a more oblique angle and thus penetrate less, and the bright sun season is shorter. For these reasons alone, the plankton crop could be expected to be smaller. Then add the fact that Wollaston is on the Pre-Cambrian Shield, whereas Last Mountain Lake is in the center of an extensive sedimentary basin. It follows automatically that the mineral content of Last Mountain Lake is considerably higher than that of Wollaston, with consequent greater ability to produce plankton. Then consider the factor of topography. Wollaston is a deep lake, with bays sheltered by rocky shores often well

timbered, and with many rocky timbered islands to break the flow of the wind. Last Mountain Lake, on the other hand, is narrow, moderately shallow, and extends like a finger pointed almost in the direction of the prevailing wind. In consequence of these factors, Wollaston Lake water is little affected by wind. Except in the spring and fall overturns, Wollaston has areas deficient in oxygen. Last Mountain Lake, on the other hand, is churned and mixed by the wind almost constantly, and the oxygen content is high. In consideration of these facts alone, it is little wonder that Wollaston produces less fish than Last Mountain, even though it is ten times as big. Specifically, total limits on Wollaston were set at 800,000 pounds, or 1.6 pounds per acre. The total catch on Last Mountain Lake was approximately a million pounds, or 18 pounds per acre.

A thousand examples could be given of the practical results of the study of lake ecology, and illustrated with records of improved management.

Summed up, the physical environmental factors are: geographic location, local topography and morphology (shape of the lake bottom). Geographic location largely determines the climate and two important features of climate—wind and sunlight—affect plankton growth and oxygen

The shorelines of Wollaston Lake are steep and rocky, typical of shorelines in the Pre-Cambrian Shield.

Typical of the gently-sloping shorelines of many lakes in the sedimentary area are those of the northern part of Last Mountain Lake.

supply. The makeup of the drainage basin—mainly as regards soil types and run-off—affect mineralization and siltation, and thus govern to a considerable degree the ability of the lake to produce plankton, this in turn being a major factor in fish production. The morphology of a lake is a deciding factor as regards shallow-water and deep-water species, both predators and forage fish, as well as plant growth, oxygen supply, etc.

With the physical factors in mind as interrelated facets of the ecology of a lake, it becomes possible to fit the living organisms into the picture. The fish-producing food chain is of special interest to the fisheries biologist. It functions roughly as follows, but with endless variations:

Plant plankton grows on minerals. The plant plankton and the smaller, simpler animals that graze on it are devoured by more complex animal plankton like the rotifers, and some of these are in turn eaten by the predator plankters like cyclops. All young fish and most of the smaller fish species feed on plant and animal plankton, as do the adults of a few species, like cisco, that are equipped with gill strainers suitable for garnering plankton. Bottom organisms, such as bloodworms, molluscs, small shrimps, etc., feed on decaying plankton in the ooze, and are themselves used for food by bottom-feeders like whitefish and suckers. Predatory fish eat the bottom feeders and the plankton eaters, as well as other small predators. Man or other land animals or birds catch a small portion of all these fish, and the rest die, decay and once again become minerals to help nourish a crop of plankton. Unused plankton and bottom fauna also decay and become inorganic minerals, enriching the water for continuing

growth. There are literally scores of different food chains in a freshwater lake.

This, in the simplest terms, is a picture of life in a fresh-water lake, as it is lived by the species most important for the production of fish. Hundreds of species exist in a lake, in addition to those plants and animals named in this booklet, and each plays its minor part in relation to the lake and to the great fish-producing species. The practical fisheries biologist must ignore most of these, or he would become hopelessly lost in a welter of data.

Laboratory examination of bottom organisms indicates the amount and type of food available in a lake for bottom-feeding fish.

CONCLUSION

Fisheries research is a new science, and one that has received very little publicity. However, its usefulness in fisheries management is seldom disputed by those who have seen the results. In simple terms, a biological research job on a lake means that decades of costly trial and error in the management of that lake may be avoided.

In order of importance, the basic tasks of the fisheries researcher in relation to management, are: To assess the populations of the various species in a lake; to estimate the amount of fishing permissible if healthy populations are to be maintained; to deduce if any detrimental factor obtains in a lake which might be rectified by heavy fishing of a certain species or the possible introduction of a new species. The biologist must be aware of the far-flung effects of any decision that may change the population (or population ratio) in a lake. The biologist is able to recommend the mesh sizes desirable for commercial fishing on a lake, and he can recommend a sound balance between commercial fishing and angling, keeping in mind that fish caught by anglers bring tourist operators perhaps ten times the gross revenue that accrues to the commercial fishermen, but keeping in mind also that in most of the northern lakes angling pressure is not yet heavy enough to harvest even a small fraction of the total allowable crop.

No fisheries biologist pretends that his is an exact science. However, allowing a reasonable margin of error, the biologist can state within limits that a given quantity of fish of certain species may be harvested annually from a given lake. And he can offer pertinent suggestions regarding such matters as stocking, coarse fish removal, desirable relationship of commercial fishing and angling, and so on. In short, the information provided by the limnologist can be weighed and employed by the fisheries administrators in such a manner as to reduce to a very substantial degree the extremely expensive chance factor in fisheries management.

As the angling pressure multiplies during the coming decade or so, and the demand for commercial fish creates pressure for larger limits on more lakes, the tempo of limnological research must inevitably increase, in order that soundly-based management policies may not lag behind the need for them. The results of mismanagement are catastrophic to the production capability of a lake. Conversely, scientific, sane management policies ensure the optimum long-term production from Saskatchewan's multitude of superb water bodies.

Prepared by D. F. Symington in co-operation with F. M. Atton, Senior Biologist of the Fisheries Branch, Department of Natural Resources.

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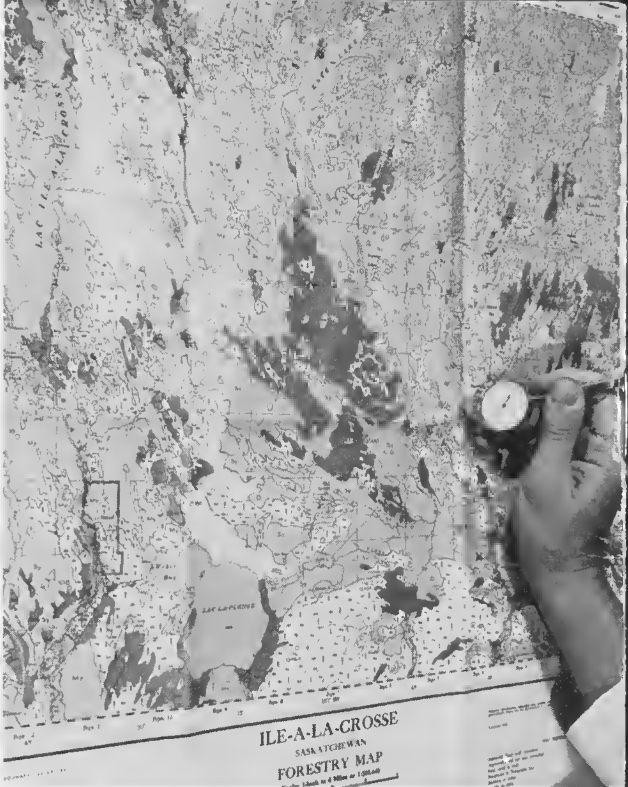
The shoreline is measured from a map by means of a "meter wheel." The extent of shoreline is a major factor in determining the food supply in any lake.



A fisheries research team using a seine net to collect samples of small fish.